

This excerpt is from the project entitled Thermobile running a car's air-conditioning while idling the engine for long periods of time.

*This entry would be likely to receive a **score of 2**, based on the EDPPSR. In this entry, the problem is identified only somewhat clearly and objectively and only minimally elaborated. The justification of the problem reflects the concerns of two stakeholders (car owners explicitly, and by inference, the nation as a whole, for whom idling cars impacts both the economy and the environment). The justification may be regarded as biased, however, because only a single source was consulted (an environmental and musical education organization website). There is no detail provided to demonstrate that this source is either timely or credible. The justification of the problem in this entry does, however, offer enough objective information to allow for the determination of at least a few measurable design requirements.*

The entry as a whole could be improved with the addition of more explicit connections between the problem statement and justification. As it stands, the justification takes the form of a small series of bullet points capturing key facts from the single source referenced and the inclusion without comment of one complete article from a website. In addition, the justification could have more explicitly highlighted the concerns of primary stakeholders and could have been based on additional sources (particularly technical and/or professional journal articles). For scores in the higher range, the timeliness and credibility of sources should be made clear by the student(s) undertaking the design project.

Two instructional issues are worth noting here:

- 1) to score decisions for Elements A-L, to the extent that errors in the problem statement may confuse readers and interfere with meaning, they may have some impact. Statements like use of and do not help convey a clear and effective problem statement.*
- 2) Students may need direct and sustained instruction on locating, selecting, and using sources, particularly those from the Internet. In addition, they must develop summary and synthesis skills so that they are always in control of the information they provide do their talking for them. This is important since it is impossible for a reviewer examining the entry contents to determine what effect the supplied resources had on the vision of the project or what specific evident the students wish the reviewer to consider.*

**Engineering Design Process Portfolio Scoring Rubric
Component and Element Titles**

Component I: Presenting and Justifying a Problem and Solution Requirements

- **Element A: Presentation and justification of the problem**
- Element B: Documentation and analysis of prior solution attempts
- Element C: Presentation and justification of solution design requirements

Component II: Generating and Defending an Original Solution

- Element D: Design concept generation, analysis, and selection
- Element E: Application of STEM principles and practices
- Element F: Consideration of design viability

Component III: Constructing and Testing a Prototype

- *Element G: Construction of a testable prototype*
- Element H: Prototype testing and data collection plan
- Element I: Testing, data collection and analysis

Component IV: Evaluation, Reflection, and Recommendations

- Element J: Documentation of external evaluation
- *Element K: Reflection on the design project*
- Element L: Presentation of designer's recommendations

Component V: Documenting and Presenting the Project

- Element M: Presentation of the project portfolio
- Element N: Writing like an Engineer

Element A: Presentation and justification of the problem

5 The problem is clearly and objectively identified and defined with considerable depth, and it is well elaborated with specific detail; the justification of the problem highlights the concerns of many primary stakeholders and is based on comprehensive, timely, and consistently credible sources; it offers consistently objective detail from which multiple measurable design requirements can be determined.

4 The problem is clearly and objectively identified and defined with some depth, and it is generally elaborated with specific detail; the justification of the problem highlights the concerns of some primary stakeholders and is based on various timely and generally credible sources; it offers generally objective detail from which multiple measurable design requirements can be determined.

3 The problem is somewhat clearly and objectively identified and defined with adequate depth, and it is sometimes elaborated with specific detail, although some information intended as elaboration may be imprecise or general; the justification of the problem highlights the concerns of at least a few primary stakeholders and is based on at least a few sources which are timely and credible; although not all information included may be objective, the justification of the problem offers enough objective detail to allow at least a few measurable design requirements to be determined.

2 The problem is identified only somewhat clearly and/or objectively and defined in a manner that is somewhat superficial and/or minimally elaborated with specific detail; the justification of the problem highlights the concerns of only one or two primary stakeholders and/or may be based on insufficient sources or ones that are outdated or of dubious credibility; although little information included is objective, the justification of the problem offers enough objective detail to allow at least a few design requirements to be determined; however, these may not be ones that are measurable.

1 The identification and/or definition of the problem is unclear, is unelaborated, and/or is clearly subjective; any intended justification of the problem does not highlight the concerns of any primary stakeholders and/or is based on sources that are overly general, outdated, and/or of dubious credibility; information included is insufficient to allow for the determination any measurable design requirements.

0 The identification and/or definition of the problem are missing OR cannot be inferred from information included. A justification of the problem is missing, cannot be inferred from information included as evidence, OR is essentially only the opinion of the researcher.



Thermobile

PRESENTATION AND JUSTIFICATION OF THE PROBLEM A

Problem:

Currently, if a driver that is parked, is not able to use the air conditioning of the car without the engine on. This is due to the fact that the main unit in the air conditioning system, the compressor is directly connected to the engine and is only powered when the engine is on. The compressor is powered by the engine as it is connected to the engine serpentine belt.

During the uncomfortable days of the summer season, drivers leave the engine running just for the purpose of wanting the air conditioning system to be on. Millions of gallons of gas are used up in just the United States for this just of voluntary idling and for the purpose of climate comfort in their cars.

Justification: (Hinkle Charitable Foundation)

- The average family could save between \$113 to \$241 by eliminating 5 minutes of idling each day depending on engine size. (3.15 per gallon)
- 3.8 million gallons of gasoline are wasted every day from voluntary idling which excludes idling while in traffic.
- While eliminating 5 minutes of idling each day can save hundreds of dollars, it will also reduce your environmental footprint by 220lbs to 440lbs of CO2 per year.

Direct Reductions from Eliminating 5 minutes of Idling

Engine Size	Daily	Annual		
	Gasoline Not Burned	Gasoline Not Burned	Money Not Spent	CO2 Not Emitted
Small	.5 cups	10 gallons	\$30	220 lbs.
8 Cylinder	1 cup	20 gallons	\$60	440 lbs.

<http://www.thehcf.org/antiidlingprimer.html>

- Although it may seem as though idling for just 5 minutes has no real effect, collectively as a country, 1.4 billion gallons of gas and 13 million tons of CO2 are wasted annually.
- Not only does idling waste unnecessary gas and emits unnecessary CO2, but is bad for the cars engine and the cars mileage by leaving residues behind when the gasoline doesn't undergo complete combustion.

Anti-Idling Primer *Every Minute Counts*

MYTH VS. REALITY

Old habits are hard to break. To most, idling a car may seem fairly innocuous, but it is actually detrimental to the modern automotive engine, wastes gasoline, and is often done based on mistaken assumptions or outdated logic, or simply out of habit. Each day, Americans waste approximately 3.8 million gallons of gasoline by voluntarily idling their cars. While all idling is bad for the car engine, this primer addresses only voluntary idling, which occurs when the car is not actually being driven in traffic. (Of course, the best way to address involuntary idling, which occurs in traffic, is to buy a hybrid, but we realize that most people are not yet ready to sell their conventional cars and replace them with non-idling hybrids.) There are, however, easy steps owners of conventional cars can take to help the cause.

Myth 1: Cars should run in an idling mode for several minutes before being driven.

Wrong. Modern engines do not need more than a few seconds of idling time before they can be driven safely. Moreover, the best way to warm up a car is to drive it, since that warms up the catalytic converter and other mechanical parts of the car, in addition to the engine.

Myth 2: Each time you start your car you waste more gasoline than if you let it idle.

Wrong. Automotive engines do not operate efficiently when they idle. Experts say there is a maximum 10 second break-even rule. If you are idling longer than 10 seconds, both you and the engine are better off if the engine is turned off and restarted.

Myth 3: Repeatedly restarting your car is hard on the engine and quickly drains the battery.

Wrong. Frequently restarting your engine does negligible damage to the engine and does not drain modern batteries excessively. In fact, the opposite is true; idling an engine forces it to operate in a very inefficient and gasoline-rich mode that, over time, can degrade the engine's performance and reduce mileage.

When not actively driving, people tend to idle their cars largely for one of two reasons: either to warm up the engine before driving or to avoid wear and tear on the engine in situations that require frequent restarting, such as drive-through service lines, rail crossings, car wash lines, carpool lines, and departure from concerts and sporting events, or while talking to friends or using the cell phone. By understanding the effects of idling and reducing the practice, you can improve your car's performance, save money, and reduce needless carbon dioxide emissions.

Direct Reductions from Eliminating 5 minutes of Idling

Engine Size	Daily	Annual		
	Gasoline Not Burned	Gasoline Not Burned	Money Not Spent	CO2 Not Emitted
Small	.5 cups	10 gallons	\$30	220 lbs.
8 Cylinder	1 cup	20 gallons	\$60	440 lbs.

PERSONAL BENEFITS

Most voluntary idling is pure waste. It wastes gasoline, and therefore money, impairs the operating efficiency of our cars, and emits additional greenhouse gases. So why do we do it? Perhaps the biggest reason is that our rules of thumb for driving cars derive mostly from a time before electronic ignition became universal, and therefore are outdated. If you recall when you learned to drive, you were probably told by your parents or your instructor that turning off and on the car repeatedly would (1) wear out the battery, (2) wear out the starter, and (3) waste gas. Today, nearly every passenger vehicle engine (cars, SUVs, and pickups) uses electronic ignition and none of these three concerns exists any longer.

First, batteries have evolved. Early battery death is no longer common, and we don't have to carry jumper cables like we once did. Today, batteries use less power per engine start, have greater power reserves, and recharge faster than they used to. Second, starters are stronger and more reliable today than they once were. Research reported by Natural Resources Canada (Canada's equivalent of the US Department of Energy) suggests that the increased wear and tear on the battery and starter that may result from more frequent restarting of the engine due to the elimination of voluntary idling costs less than \$9 US per year. Third, regarding gasoline consumption, engineers now estimate that only if an engine is restarted within 5 to 10 seconds of being turned off is it more fuel efficient to leave it running. This leads to the 10-second

rule mentioned above: ***If it looks like you will be idling for longer than 10 seconds, turn off the engine and restart when you are ready to drive.***

Not only is the common perception that we are doing something beneficial when we idle our car engines wrong, the fact is that this outdated habit actually harms the car engine, our wallets, and the environment. When an engine idles it is not running at its optimum operating temperature and condition. This results in the incomplete combustion of gasoline that can leave fuel residues on the spark plugs, the cylinder walls, and other engine parts. These residues can corrode the engine parts, thereby shortening the life of the system, and can impair fuel efficiency when driving by as much as 4 to 5% according to Natural Resources Canada. When we idle we are neither protecting our car engines nor saving fuel. Rather, we are degrading the engine's ability to operate smoothly and efficiently while actually wasting gasoline.

Estimates of the amount of time we voluntarily idle each day we drive range from 5 to 10 minutes per car. The table below summarizes the savings realized by eliminating 5 minutes of idling each day. In just 5 minutes of idling we can burn between a half and a whole cup of gasoline, depending on engine size. Over the course of a year this adds up on average to as much as 10 to 20 gallons of gas. By not voluntarily idling 5 minutes per day, we can save between about \$30 and over \$60 per year per vehicle, assuming a price of \$3.15 per gallon of gas.

In addition to these direct savings, to estimate the total financial impact of reducing voluntary idling, two additional factors must be added in. First, as noted above, wear and tear costs from the increase in engine restarts need to be considered. Second, there is also the reduced fuel efficiency and possibly shorter engine life that result from voluntary idling. For the average personal vehicle (car, SUV, and light truck) for the average mileage driven for each vehicle type, the estimated reduced efficiency results in an additional \$42 to \$83 per year in fuel costs.

Total Financial Benefit from Eliminating 5 Minutes of Voluntary Idling

Engine Size	Annual			Total	
	Direct Fuel Savings	Indirect Fuel Efficiency	Wear and Tear Cost	Per Car	Per Family
Small	\$30	\$42	-\$9	\$63	\$113
8 Cylinder	\$60	\$83	-\$9	\$134	\$241

Given that an average US family has approximately 1.8 cars, the total benefits of eliminating 5 minutes of idling each day could range from \$113 to \$241 per family. Accepting that several approximations have been used in preparing these estimates, the numbers still suggest that there can be meaningful financial savings. At a minimum, the savings are enough to pay for a nice dinner out each year for an average US family.

Did you know...that idling for more than a few seconds is actually bad for the engine and for your car's mileage?

ENVIRONMENTAL BENEFITS

Voluntary idling is one of the many daily actions that seem negligible but that, when taken cumulatively, can have a large impact on total emissions of carbon dioxide and on the environment more generally. The pernicious impact of idling has long been recognized. Many countries have pursued anti-idling initiatives, including a nationwide campaign in Canada and regional campaigns in Japan and Great Britain. Domestically, at least 13 states have state-wide anti-idling laws, and scores of counties and cities have their own anti-idling rules. For a summary of anti-idling regulations in the US, see: <http://epa.gov/smartway/documents/420b06004.pdf>

Historically, the relatively few US anti-idling campaigns have been directed at reducing idling of diesel and other commercial trucks and portside idling of ocean-going ships in certain commercial seaports. These types of idling are easy to identify, since they are usually visible, noisy, and smelly. They are also easy to attack because they do not affect the driving convenience and patterns of the everyday driver. Around the country, local activists have pressed for school district anti-idling campaigns in connection with school bus fleets. Ironically though, these recently adopted anti-idling campaigns do not target the parents in the pick-up and drop-off lanes. (When Scheller Hinkle, Hal's daughter, was co-president of the Earth Club at her high school, a specific car pool lane anti-idling campaign was launched with curb-side signs and an article in the school paper. The reaction was surprisingly good.)

Not surprisingly, passenger vehicles have seldom been included in state or local anti-idling regulations. When passenger cars are included (e.g., New Jersey and New York City), the minimum idling time that triggers penalties has been set at three minutes or more—which we now know is many times the optimal amount, financially or environmentally. In any event, failing Federal participation, local regulations are not a viable answer since they are seldom enforced. Therefore, our best hope is to appeal to our personal interests through education and increased awareness.

In the first table, we estimated that average annual carbon dioxide (CO₂) emissions from 5 minutes of daily idling ranged from 220 lbs to 440 lbs per year, depending on engine size. Given that each US household or family has 1.8 passenger vehicles, on average, this translates to approximately 400 lbs to 800 lbs of reduced carbon dioxide emissions per family if they can eliminate 5 minutes of voluntary idling each day.

As mentioned above, the pure waste that results from needless voluntary idling is most easily seen on a cumulative basis. Estimates shown in the table below are telling. On a daily basis, Americans as a whole may be burning as much as 3.8 million gallons of gasoline from voluntary idling, which, in turn, results in producing about 40,000 tons of carbon dioxide. Annually, the cumulative effect is staggering, as we may be uselessly burning 1.4 billion gallons of gasoline and emitting 13 million tons of carbon dioxide as a result.

**Total US Environmental Benefit from
Eliminating 5 Minutes of Voluntary Idling**

Daily		Annually	
Gasoline Not Burned	CO ₂ Not Emitted	Gasoline Not Burned	CO ₂ Not Emitted
3.8 million gallons	40,000 tons	1.4 billion gallons	13 million tons

When talking about the ills of idling, we've heard a number of people dissent for two reasons. First, they comment that the pollution produced in the first moments after a car is started is far worse than when it is running. There is some truth in this argument, but it misses a key point with voluntary idling. Catalytic converters, which are present in all passenger vehicles sold in the US, break down toxic pollutants like nitrogen oxides, carbon monoxide and carcinogenic hydrocarbons. They do this by exposing the exhaust to certain metal catalysts at very high temperatures, ranging from about 750°F to 1,500°F. When the car is not fully warmed up the converter does not operate efficiently, and this leads to the perception of heavy emissions immediately after starting a car. To work properly, the converter must be heated up to its operating range, yet idling does not do this effectively, nor does it effectively warm up the other parts of the car that need to be warmed up, including the engine, tires, and drive train. Fortunately, converters, once operating in their appropriate temperature range, take as much as 25 minutes or more to lose their heat. **Thus, the best way to warm up a car is to drive it moderately for several miles within 10 seconds of starting the engine. Once the car is warmed up, any non-active traffic pause of more than 10 seconds will result in wasted gasoline, needless pollution, and possibly degradation of the car's performance and mileage.**

Second, people comment about the need to warm an engine in extremely cold weather. Again, there is truth in this point. However, in all but the coldest weather, 30 seconds of idling will normally warm the engine block and circulate the oil sufficiently. In cases of severe winter cold, as many northerners know, an engine block heater is by far the safest and most economical way to heat a very cold engine.

The city of Aspen, Colorado, launched a program called *Idling Isn't Cool*, which targets people who let their cars idle to warm them up in cold weather or while running errands. Environmental health specialists walk through town and place small, laminated placards featuring an image of the earth sweating from heat on windshields of offenders. The placard reads, "Turning off your engine when you are not driving is one of the easiest things you can do to lessen your contribution to global warming." It goes on to explain that 30 seconds of idling is ample time to get engine oil circulating. It also cites the city ordinance that makes it illegal to idle an engine for 5 minutes or more and provides a link to calculate personal carbon emissions, www.aspenglobalwarming.com/calculate.cfm.

Finally, in our discussion of voluntary idling, we have intentionally ignored idling for reasons of personal comfort. Each person can decide his or her own comfort tolerance range relative to the financial and environmental impact of involuntary

idling. However, we believe that when people are better educated and more aware of the consequences, needless voluntary idling will decline.

***Did you know...**that these are easy ways that we can all eliminate voluntary idling: while waiting for a child to get into the car, in school pick-up and drop-off lanes, while talking on cell phones, and when warming up the car in the morning.*

PERSONAL EXPERIENCE

Patricia Deacon writes: On a more personal note, in the weeks following my initial discussions with Hal about the idling issue, I thought about the ways I could reduce my own idling and possibly have a positive impact on others. In a city like Los Angeles, where driving and posing in exotic or luxury cars is considered a normal and everyday pastime, there is no shortage of wasteful idling habits. I believe raising awareness on any level is a step in the right direction toward fighting climate change, and I decided to start with myself.

Beginning with observations of my own habits, I realized that a very simple change in my own garage parking could make a difference. I live in a 9-unit townhome building where each unit has its own enclosed, attached garage within a common gated garage area. When I go to leave, I typically back my car out of my garage and close my garage door. I then have to go forward and sit and wait for the common gate to open. This takes about 15 seconds, since the transmitter incorporated into my car will not trigger the outer gate from within my unit's garage (my car needs to be facing the gate for it to respond). Instead, by backing my car into my garage when I come home, I can exit in a forward motion, triggering the outer gate at the same time, eliminating the need to back out, then go forward and wait. On average, I come and go from my garage as often as three times per day, so simply changing my parking habit can add up over time.

The biggest change I've instituted is when I'm on the cell phone in the car. Some months ago, I got into the habit of pulling over, out of traffic, when I have to take a cell call. But, until recently, I wouldn't have thought much about leaving the engine running. Now, if someone phones me while driving and I need to have the conversation, I attempt to pull over and turn the engine off. Of course, it is safer not to talk and drive at the same time, and I often need to write. Why contribute to the idling problem when I can do these things more efficiently without the engine running?

With my awareness raised, I've also recently noticed other types of wasteful idling around town. Some of the worst offenders seem to be parents and caretakers in carpool lanes, waiting to pick up kids, who can't go anywhere because they are blocked in, sometimes for 10 minutes or longer. Ninety percent are in oversized SUVs, regardless of the number of kids they are hauling, and most are on their cell phones with the windows rolled up and air conditioners, radios, and engines all running. Keep in mind; this is spring near the beach, not summer in Manhattan. The same thing goes for those leaving crowded sporting events or concerts where it can take as long to exit the parking lot as it does for intermission. It is sort of twisted to idle for 15 minutes to get out of the parking lot after a carbon-neutral concert.

Other offenders include the valet stands at hotels, restaurants, and stores. People typically pull up, leave the car running, get out, even when an attendant is nowhere in sight, only to have the valet finally show up, issue a claim check, move another car up, leave that one running as well, and juggle the cars around, all while all the engines are running.

I decided to take action close to home. One of my neighbors is a sales rep and spends an inordinate amount of time in her car and on her cell phone. The third time I saw her idling her car while she was on her phone the entire time I was driving in, backing in to my garage, and getting my mail, I thought it was time to speak up. It went something like this, "Could you do us a favor? Do you realize that if you turned your engine off, you'd wouldn't be..." She actually took the information to heart, which I found encouraging.

Although I must admit I drive an 8-cylinder car and am not quite ready to replace it with a hybrid, there are things I can do to help lessen the impact of voluntary idling. Again, I am committed to spreading the word and educating others in a tactful way. At the risk of sounding like the author Nora Ephron, in a town of excess and waste, if we all become more aware of the impact of our driving habits, we can change them; they're really not that hard to break.

***Did you know...**that you can improve your child's environment by sponsoring an anti-idling campaign*

at your local school or school district? Visit <http://www.epa.gov/otag/schoolbus/antiidling.htm#irk> or <http://oee.nrcan.gc.ca/transportation/personal/idling.cfm?attr=0>

- Hal Hinkle, Patricia Deacon, Kasia Duda